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PATENT & TRADEMARK OFFICE

FIG. 1

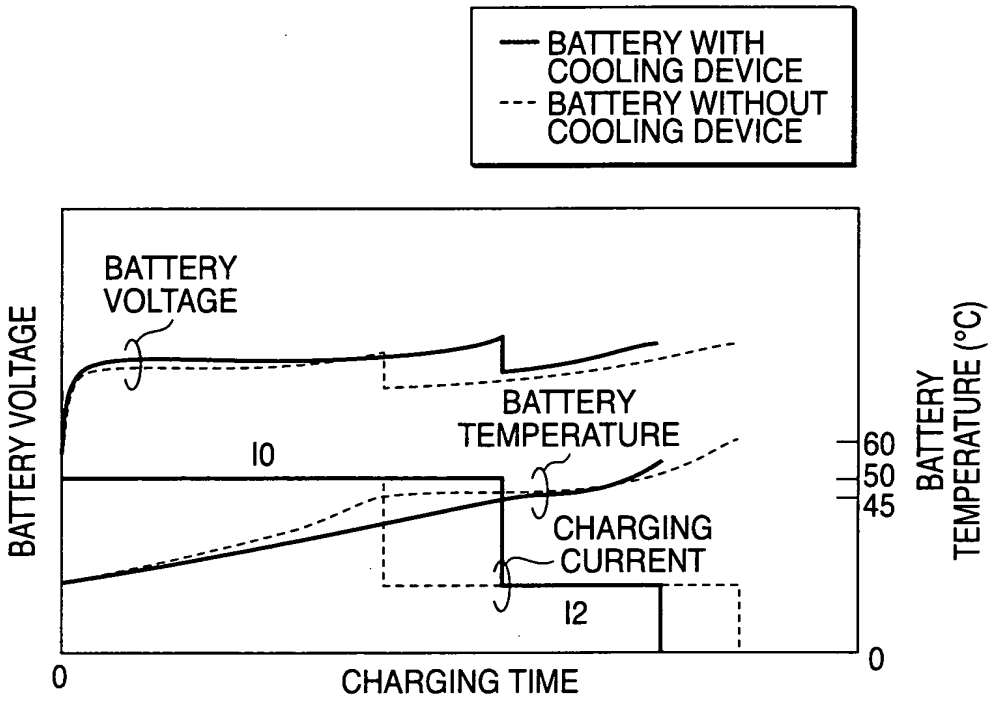


FIG. 2

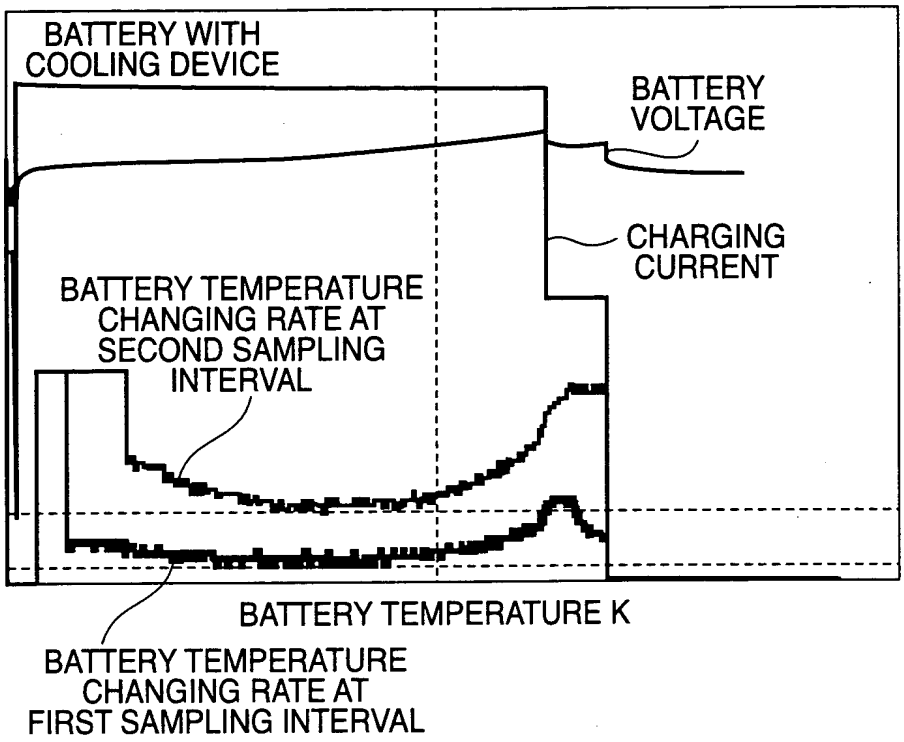

BATTERY WITH COOLING DEVICE
BATTERY VOLTAGE
CHARGING CURRENT
BATTERY TEMPERATURE CHANGING RATE AT SECOND SAMPLING INTERVAL
BATTERY TEMPERATURE K
BATTERY TEMPERATURE CHANGING RATE AT FIRST SAMPLING INTERVAL

FIG. 3

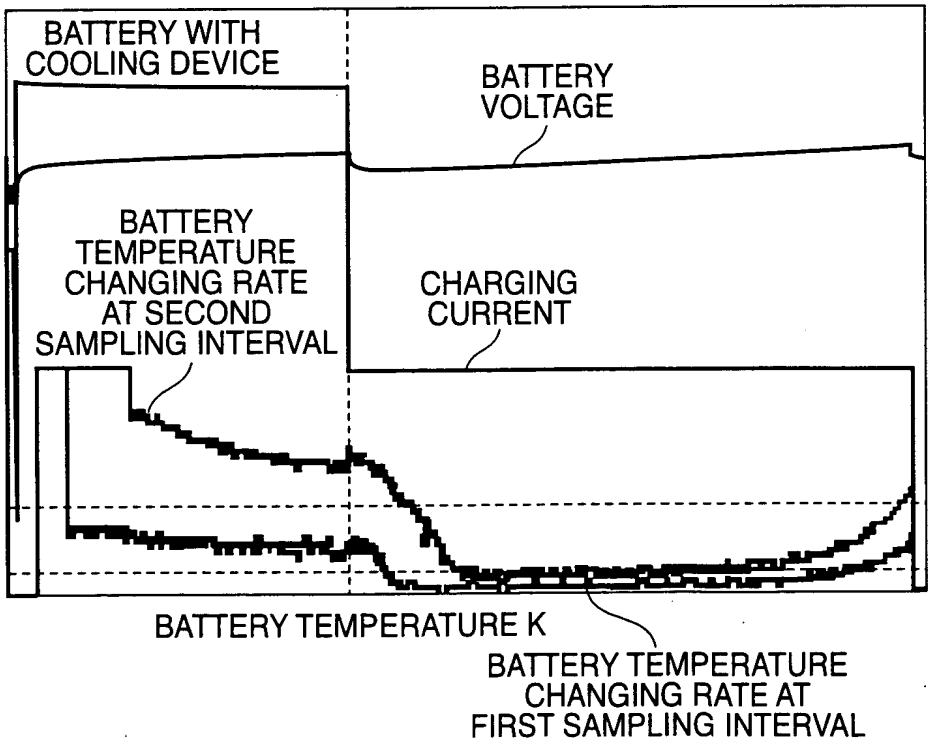

BATTERY WITH COOLING DEVICE
BATTERY VOLTAGE
BATTERY TEMPERATURE CHANGING RATE AT SECOND SAMPLING INTERVAL
CHARGING CURRENT
BATTERY TEMPERATURE K
BATTERY TEMPERATURE CHANGING RATE AT FIRST SAMPLING INTERVAL

FIG. 4

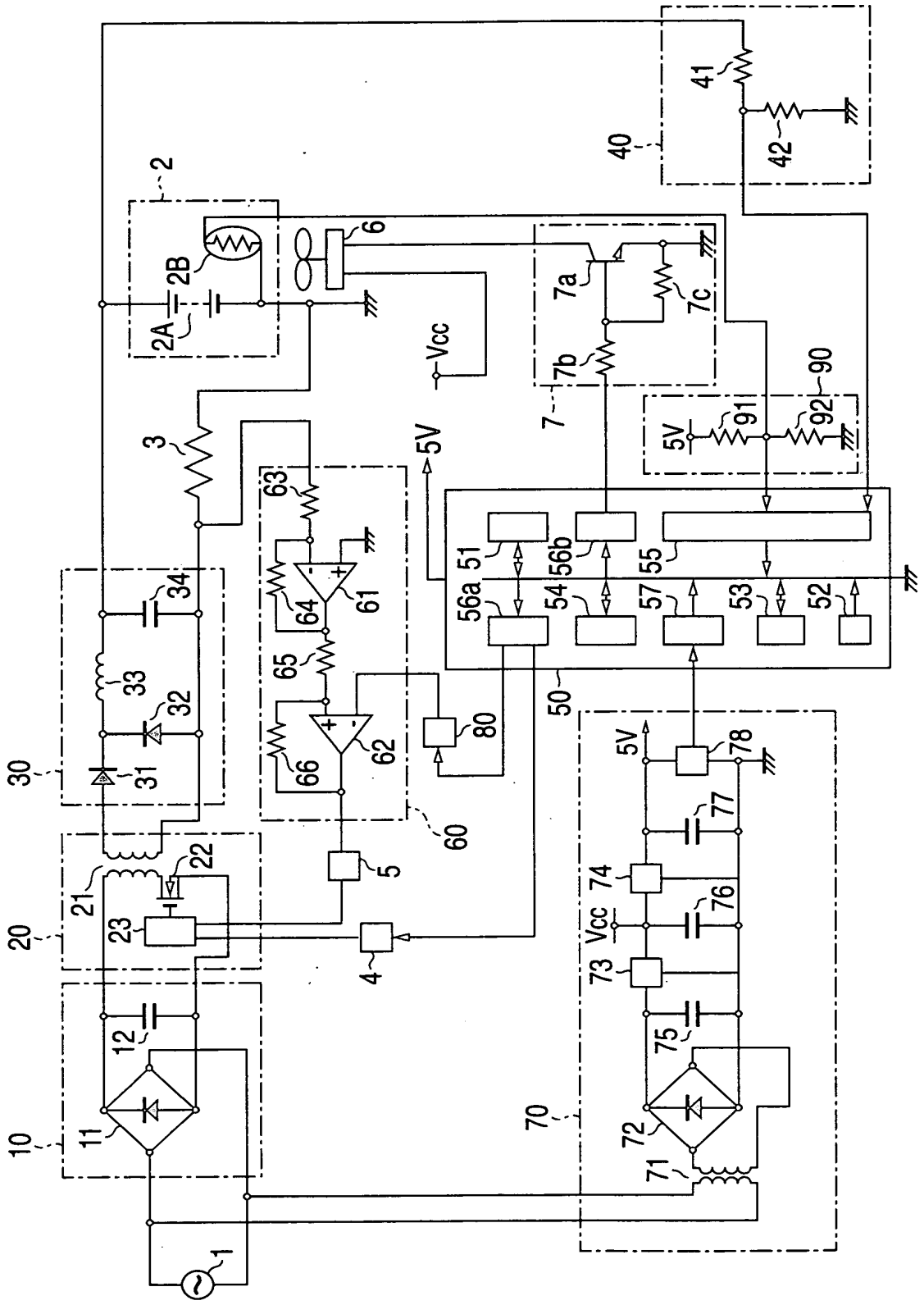
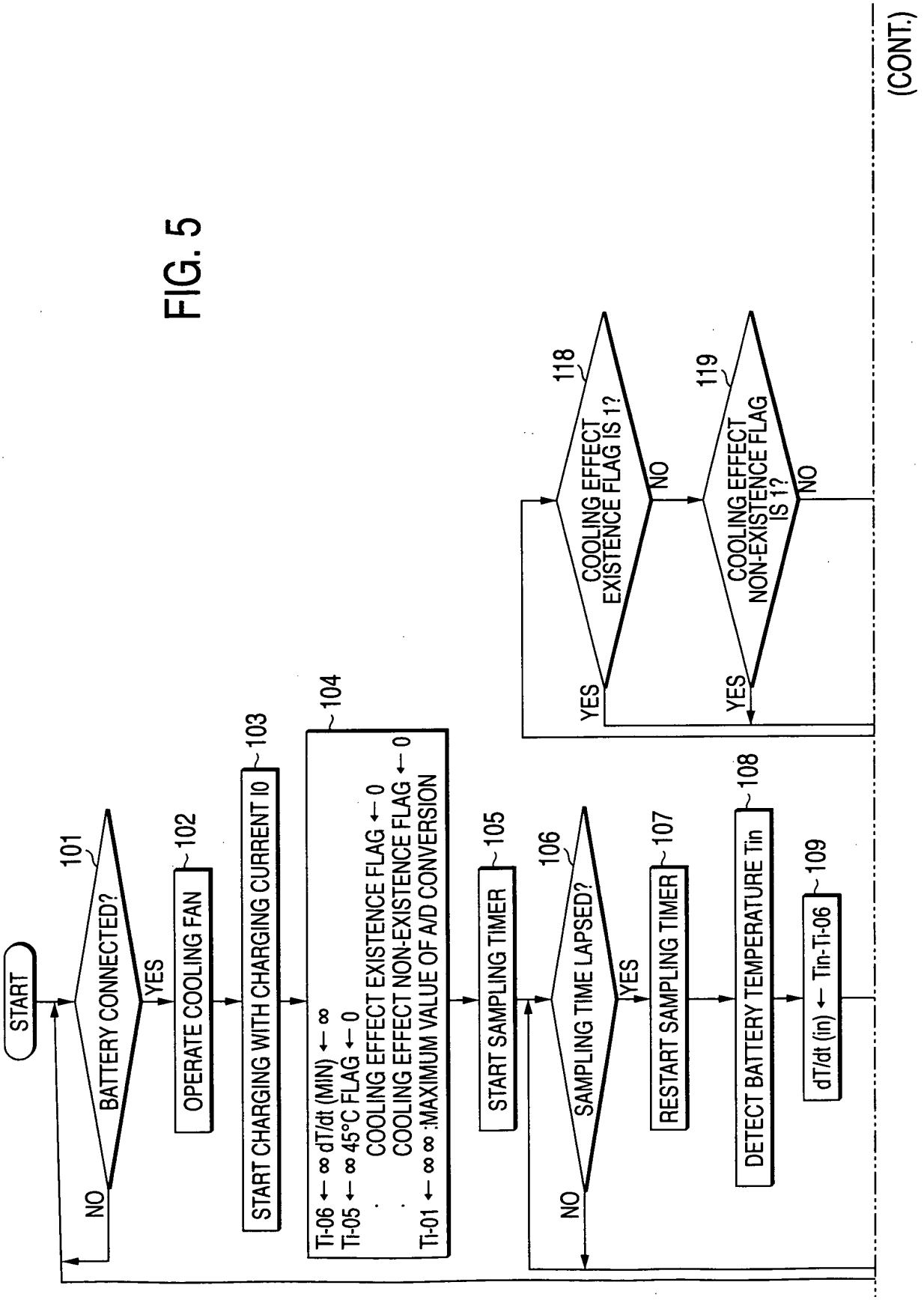

1
2
2A
2B
3
4
5
6
7
7a
7b
7c
10
11
12
20
21
22
23
30
31
32
33
34
40
41
42
50
51
52
53
54
55
56a
56b
57
60
61
62
63
64
65
66
70
71
72
73
74
75
76
77
78
80
90
91
92
Vcc
5V

FIG. 5


START
101
BATTERY CONNECTED?
NO
YES
102
OPERATE COOLING FAN
103
START CHARGING WITH CHARGING CURRENT I0
104
Ti-06 ← ∞ dT/dt (MIN) ← ∞
Ti-05 ← ∞ 45°C FLAG ← 0
COOLING EFFECT EXISTENCE FLAG ← 0
COOLING EFFECT NON-EXISTENCE FLAG ← 0
Ti-01 ← ∞ ∞ :MAXIMUM VALUE OF A/D CONVERSION
105
START SAMPLING TIMER
106
SAMPLING TIME LAPSED?
NO
YES
107
RESTART SAMPLING TIMER
108
DETECT BATTERY TEMPERATURE Tin
109
dT/dt (in) ← Tin-Ti-06
118
COOLING EFFECT EXISTENCE FLAG IS 1?
YES
NO
119
COOLING EFFECT NON-EXISTENCE FLAG IS 1?
YES
NO
(CONT.)

(FIG. 5 CONTINUED)

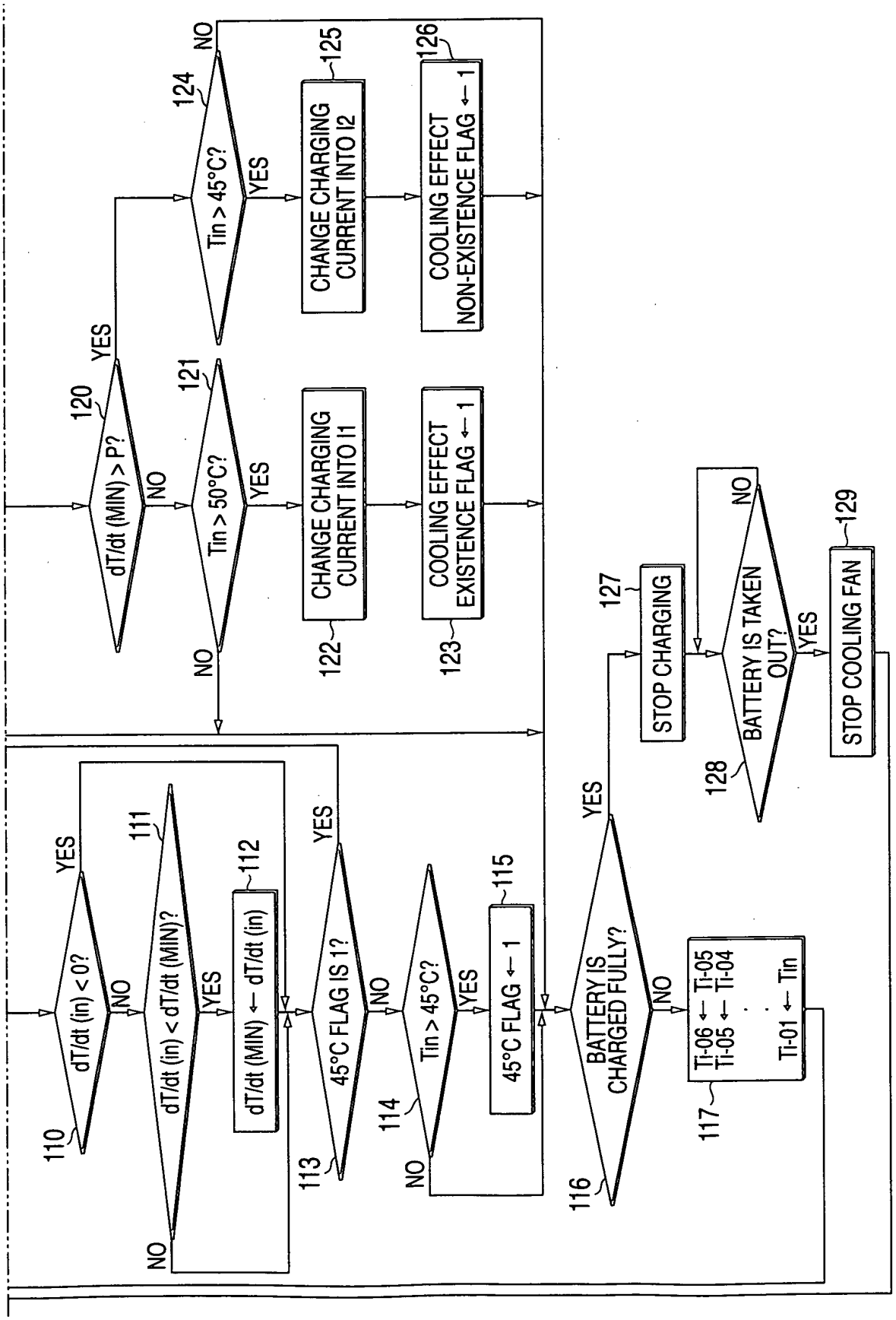


FIG. 6

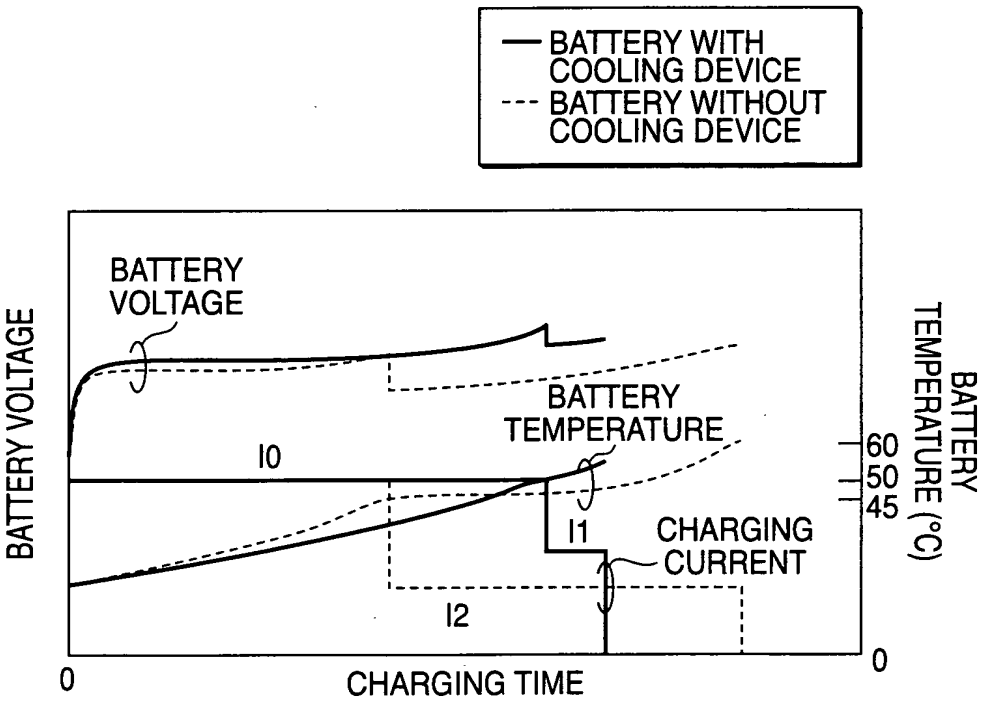

BATTERY WITH COOLING DEVICE
BATTERY WITHOUT COOLING DEVICE
BATTERY VOLTAGE
BATTERY VOLTAGE
BATTERY TEMPERATURE
I0
I1
I2
CHARGING CURRENT
60
50
45
0
BATTERY TEMPERATURE (°C)
0
CHARGING TIME

FIG. 7

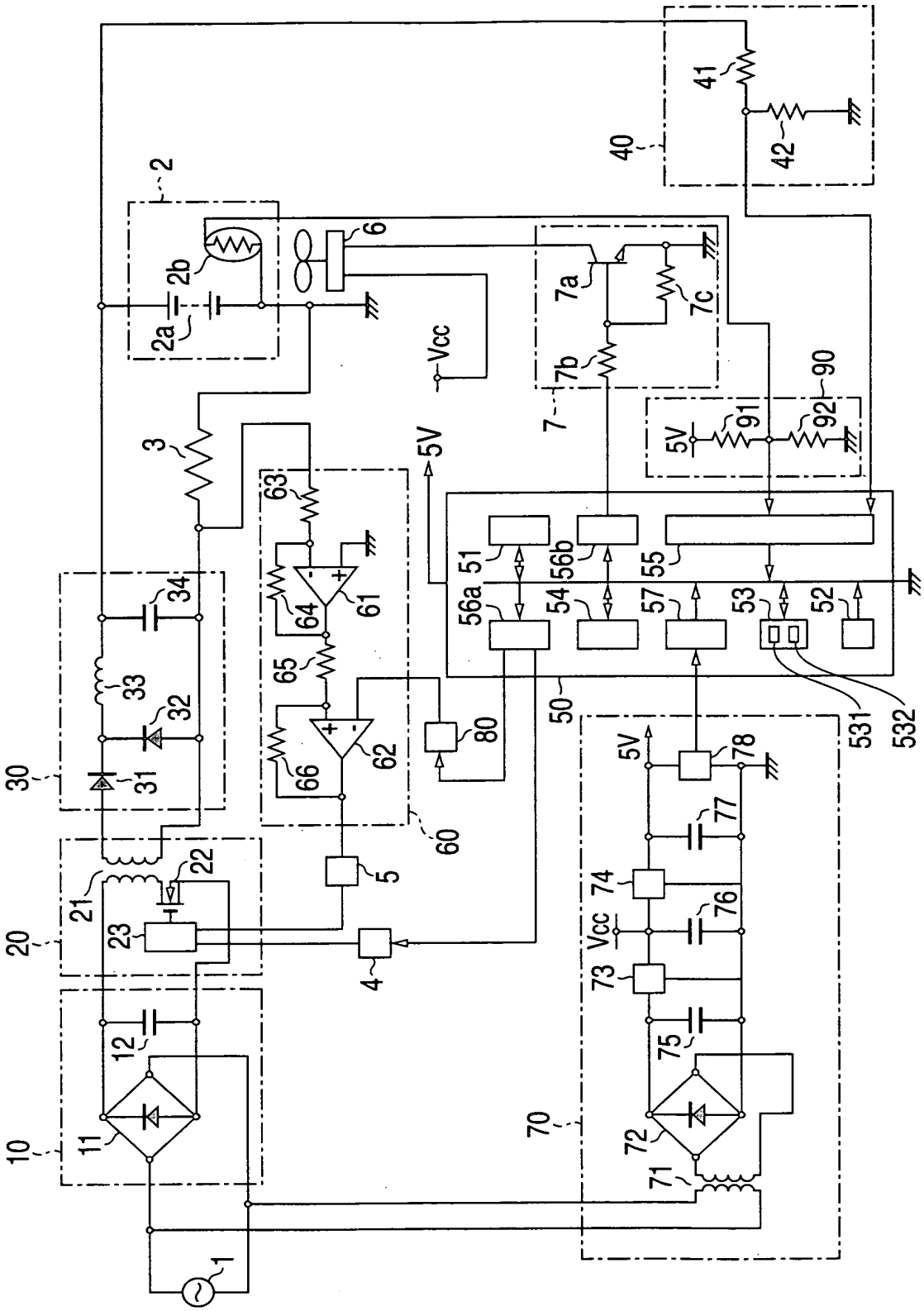

1
2
2a
2b
3
4
5
6
7
7a
7b
7c
10
11
12
20
21
22
23
30
31
32
33
34
40
41
42
50
51
52
53
54
55
56a
56b
57
531
532
60
61
62
63
64
65
66
70
71
72
73
74
75
76
77
78
80
90
91
92
Vcc
5V

FIG. 8

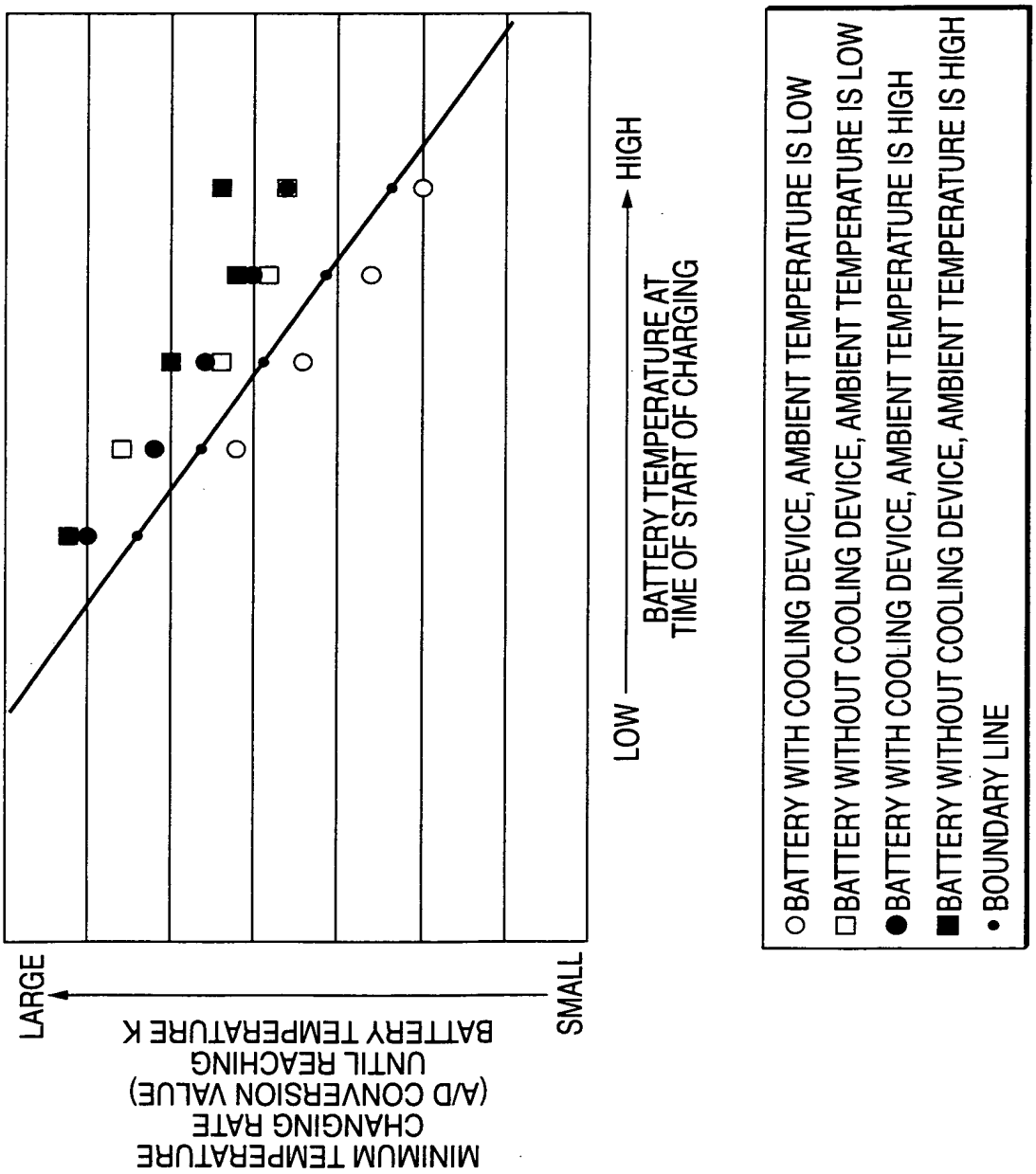
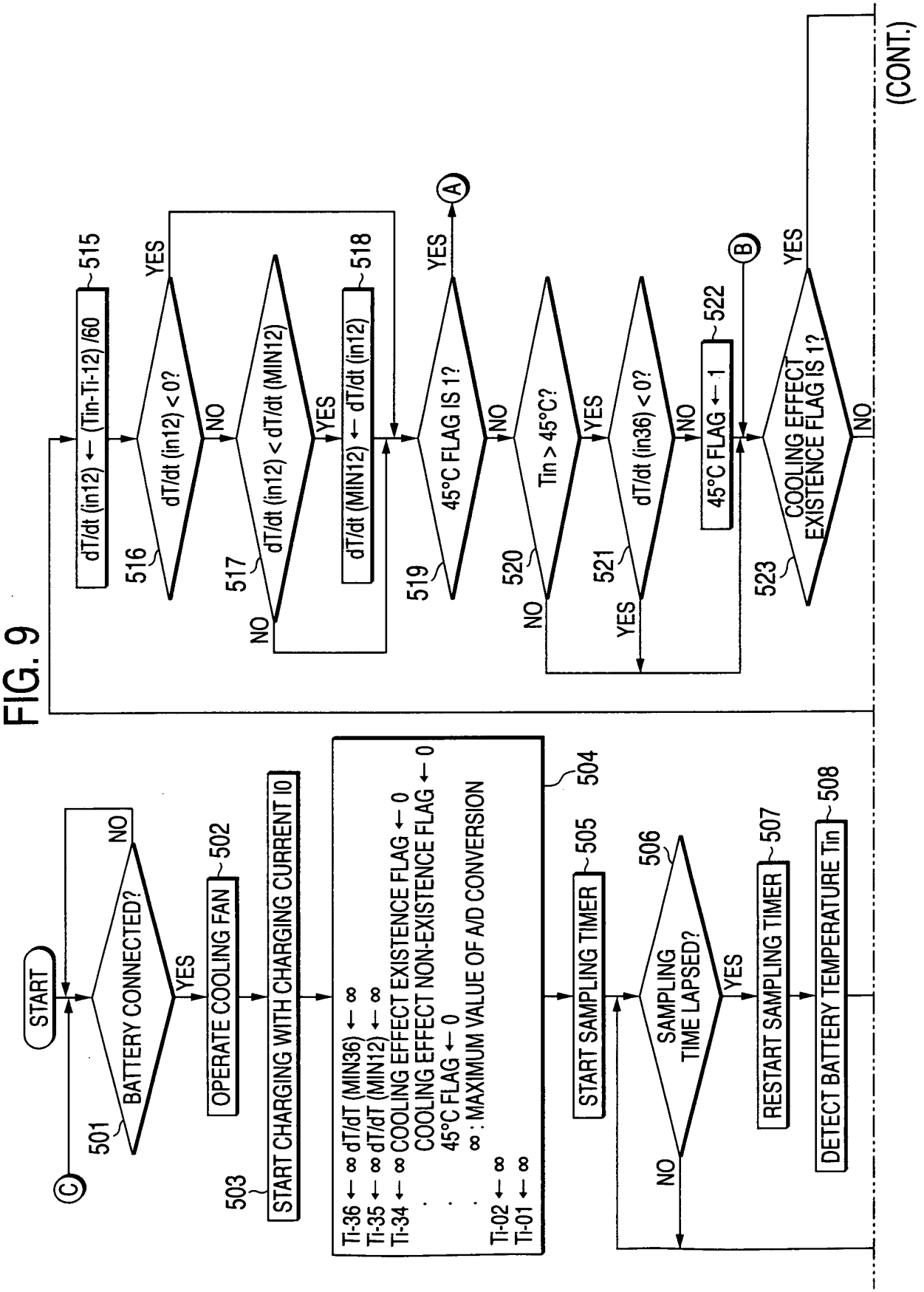

MINIMUM TEMPERATURE CHANGING RATE (A/D CONVERSION VALUE) UNTIL REACHING BATTERY TEMPERATURE K
LARGE
SMALL
LOW
HIGH
BATTERY TEMPERATURE AT TIME OF START OF CHARGING
○BATTERY WITH COOLING DEVICE, AMBIENT TEMPERATURE IS LOW
□BATTERY WITHOUT COOLING DEVICE, AMBIENT TEMPERATURE IS LOW
●BATTERY WITH COOLING DEVICE, AMBIENT TEMPERATURE IS HIGH
■BATTERY WITHOUT COOLING DEVICE, AMBIENT TEMPERATURE IS HIGH
• BOUNDARY LINE

FIG. 9


START
C
501
BATTERY CONNECTED?
NO
YES
502
OPERATE COOLING FAN
503
START CHARGING WITH CHARGING CURRENT I0
Ti-36 ← ∞ dT/dT (MIN36) ← ∞
Ti-35 ← ∞ dT/dT (MIN12) ← ∞
Ti-34 ← ∞ COOLING EFFECT EXISTENCE FLAG ← 0
COOLING EFFECT NON-EXISTENCE FLAG ← 0
45°C FLAG ← 0
∞ : MAXIMUM VALUE OF A/D CONVERSION
Ti-02 ← ∞
Ti-01 ← ∞
504
505
START SAMPLING TIMER
506
SAMPLING TIME LAPSED?
NO
YES
507
RESTART SAMPLING TIMER
508
DETECT BATTERY TEMPERATURE Tin
515
dT/dt (in12) ← (Tin-Ti-12) /60
516
dT/dt (in12) < 0?
YES
NO
517
dT/dt (in12) < dT/dt (MIN12)
NO
YES
518
dT/dt (MIN12) ← dT/dt (in12)
519
45°C FLAG IS 1?
YES
A
520
Tin > 45°C?
NO
YES
521
dT/dt (in36) < 0?
YES
NO
522
45°C FLAG ← 1
B
523
COOLING EFFECT EXISTENCE FLAG IS 1?
YES
NO
(CONT.)

(FIG. 9 CONTINUED)

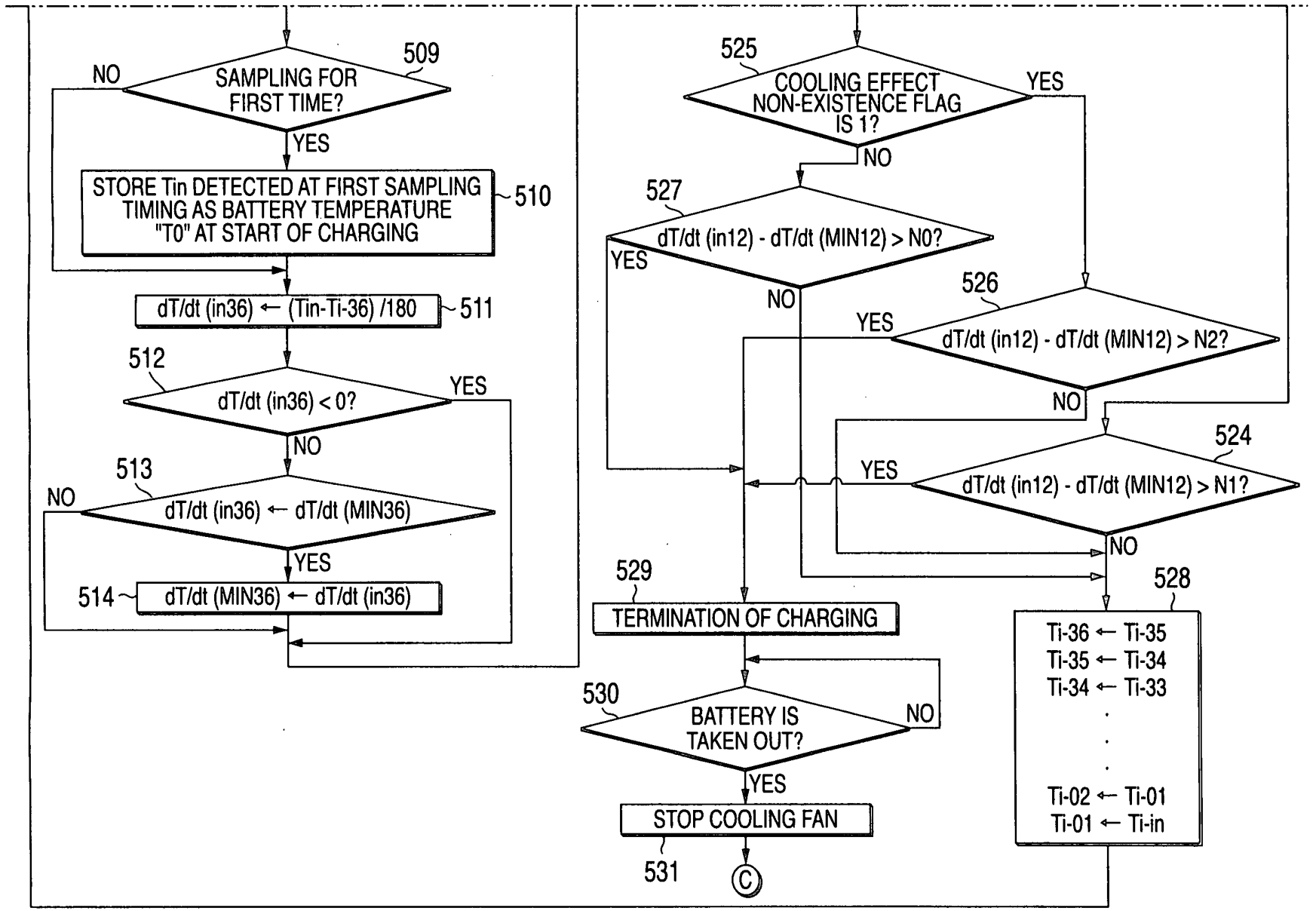


FIG. 10

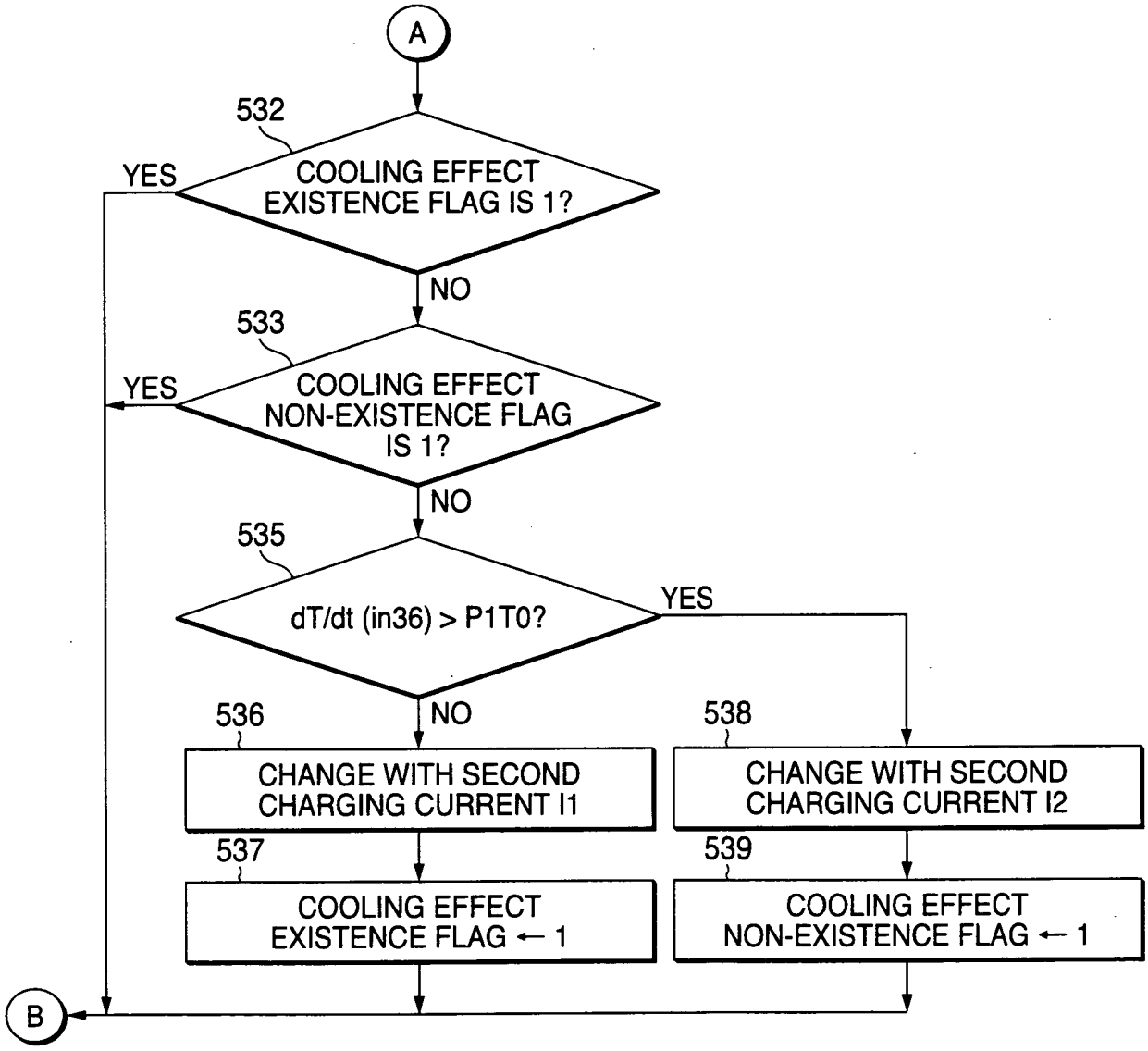
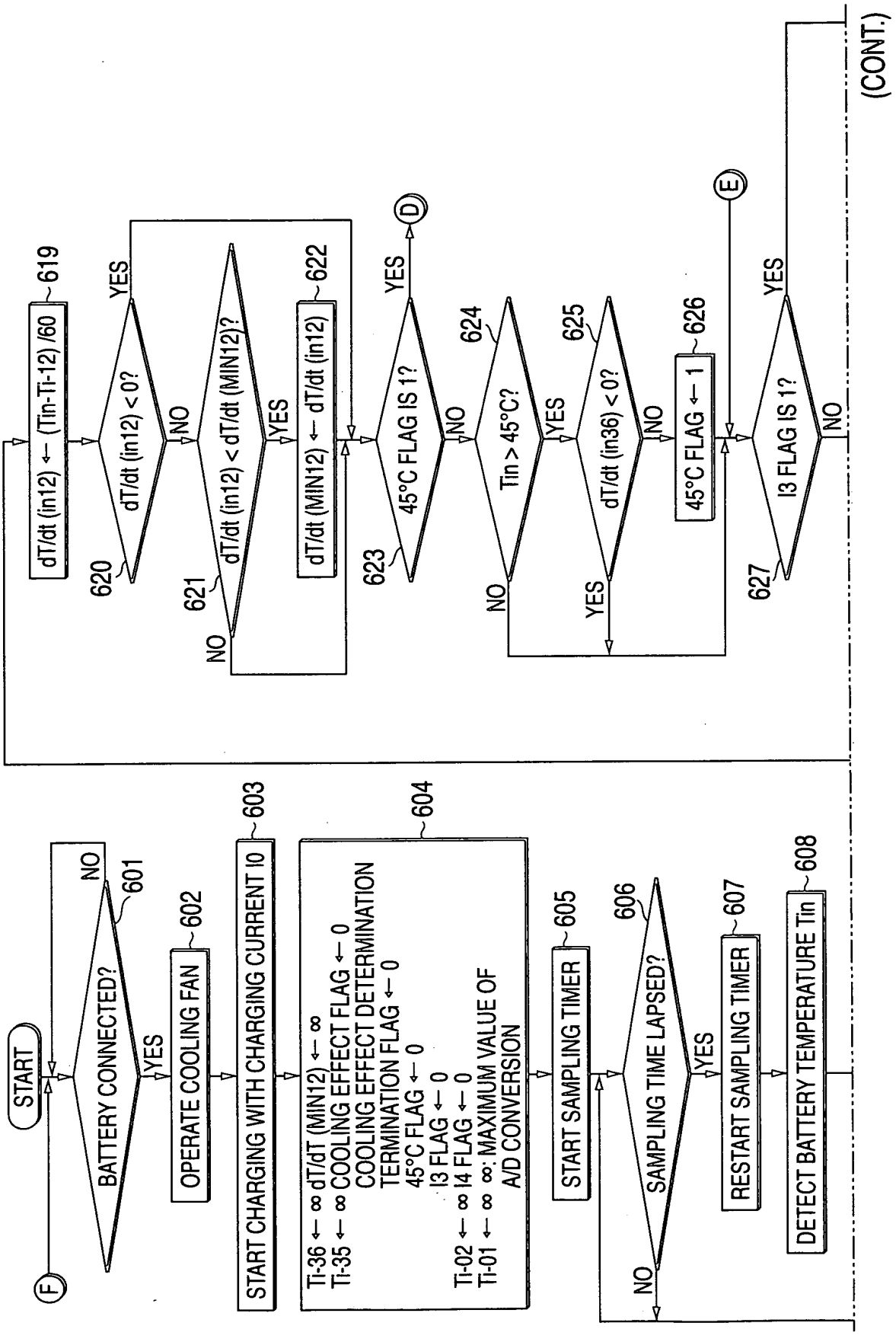

A
532
COOLING EFFECT EXISTENCE FLAG IS 1?
YES
NO
533
COOLING EFFECT NON-EXISTENCE FLAG IS 1?
YES
NO
535
dT/dt (in36) > P1T0?
YES
NO
536
CHANGE WITH SECOND CHARGING CURRENT I1
538
CHANGE WITH SECOND CHARGING CURRENT I2
537
COOLING EFFECT EXISTENCE FLAG ← 1
539
COOLING EFFECT NON-EXISTENCE FLAG ← 1
B

FIG. 11


START
BATTERY CONNECTED?
NO
YES
601
OPERATE COOLING FAN
602
START CHARGING WITH CHARGING CURRENT I0
603
Ti-36 ← ∞ dT/dT (MIN12) ← ∞
Ti-35 ← ∞ COOLING EFFECT FLAG ← 0
COOLING EFFECT DETERMINATION TERMINATION FLAG ← 0
45°C FLAG ← 0
I3 FLAG ← 0
Ti-02 ← ∞ I4 FLAG ← 0
Ti-01 ← ∞ ∞: MAXIMUM VALUE OF A/D CONVERSION
604
START SAMPLING TIMER
605
SAMPLING TIME LAPSED?
606
NO
YES
RESTART SAMPLING TIMER
607
DETECT BATTERY TEMPERATURE Tin
608
I3 FLAG IS 1?
627
NO
YES
45°C FLAG ← 1
626
E
dT/dt (in36) < 0?
625
NO
YES
Tin > 45°C?
624
NO
YES
45°C FLAG IS 1?
623
YES
D
dT/dt (MIN12) ← dT/dt (in12)
622
dT/dt (in12) < dT/dt (MIN12)?
621
NO
YES
dT/dt (in12) < 0?
620
YES
NO
dT/dt (in12) ← (Tin-Ti-12) /60
619
F
(CONT.)

(FIG. 11 CONTINUED)

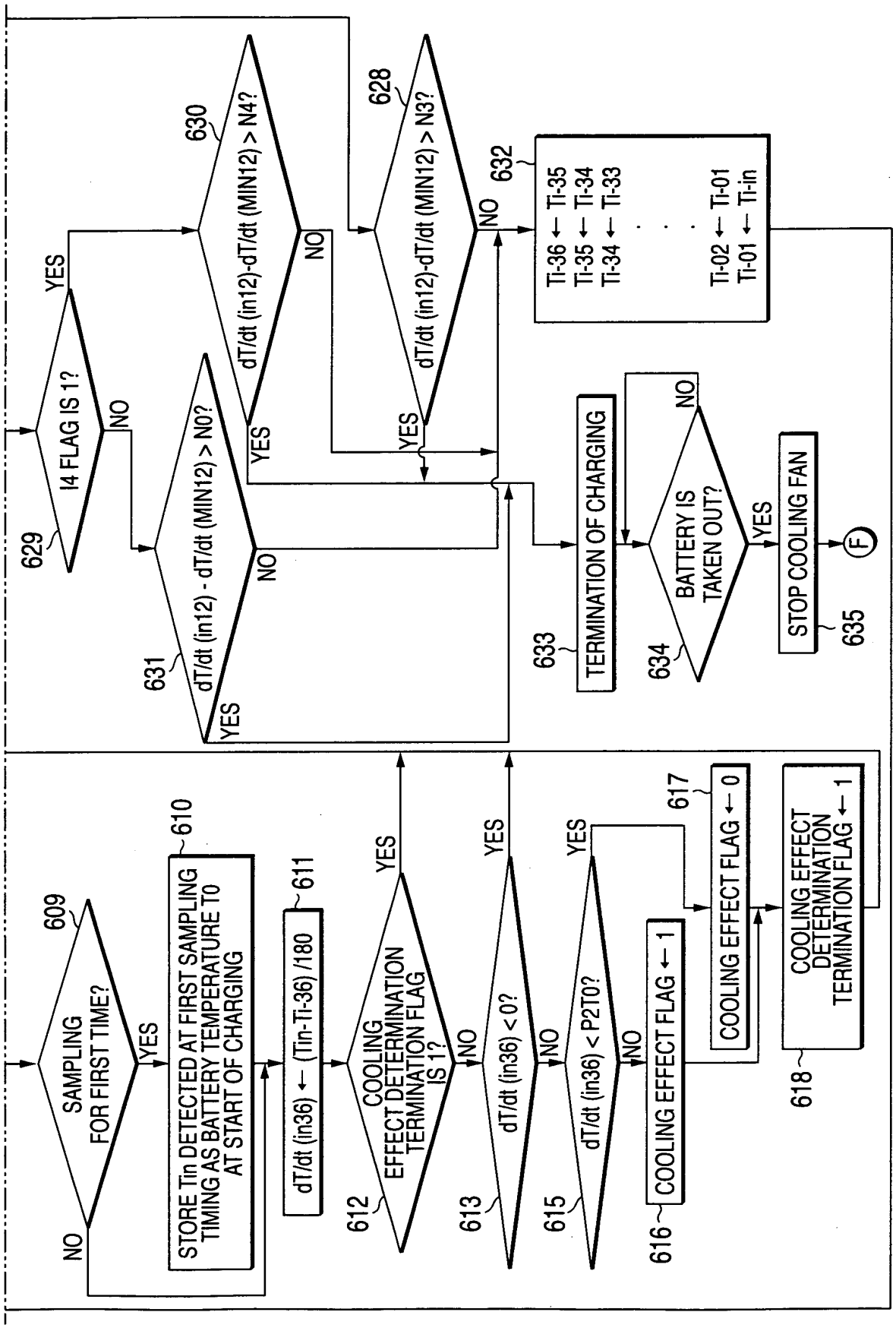
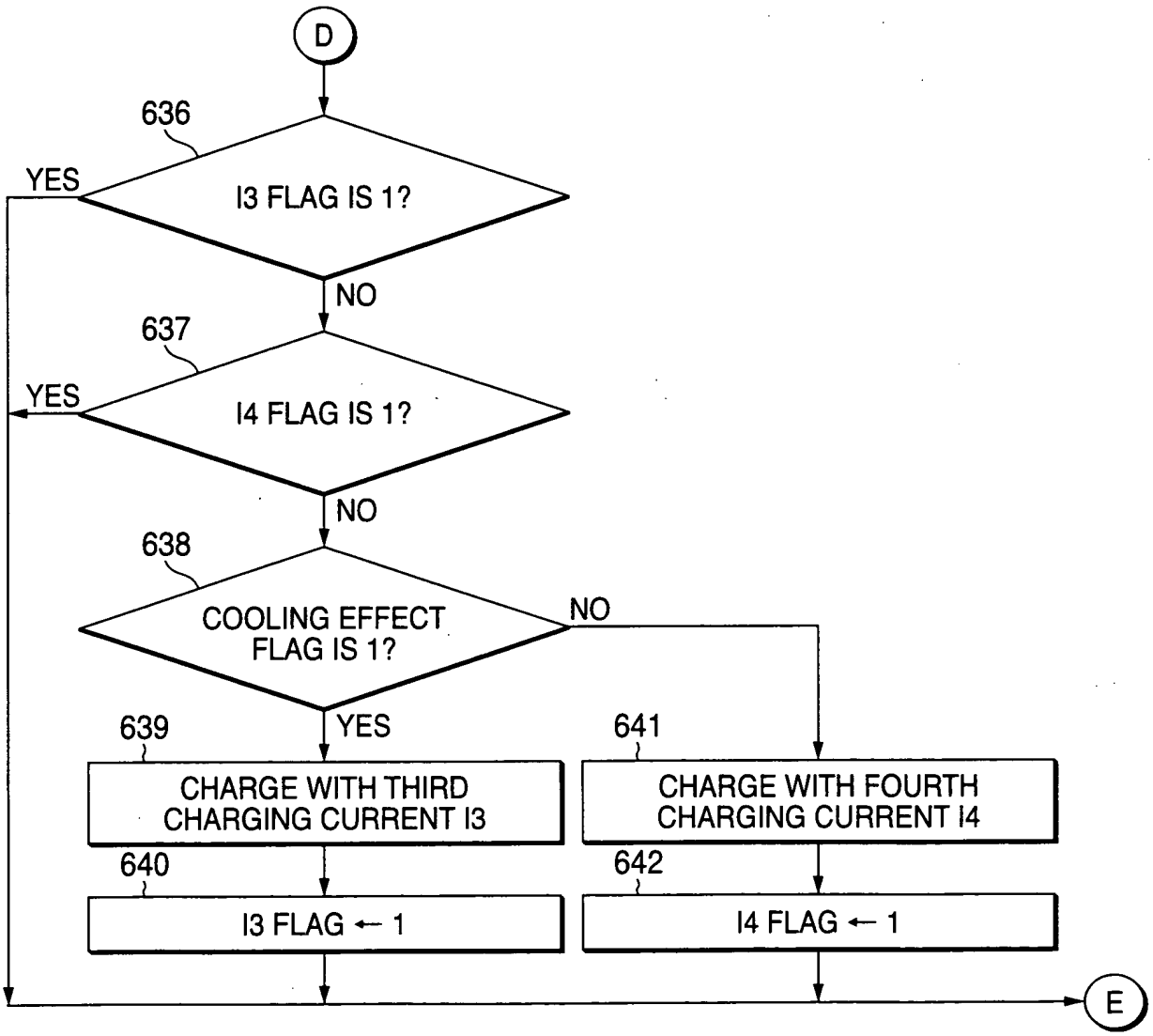


FIG. 12


D
636
I3 FLAG IS 1?
YES
NO
637
I4 FLAG IS 1?
YES
NO
638
COOLING EFFECT FLAG IS 1?
NO
YES
639
CHARGE WITH THIRD CHARGING CURRENT I3
641
CHARGE WITH FOURTH CHARGING CURRENT I4
640
I3 FLAG ← 1
642
I4 FLAG ← 1
E